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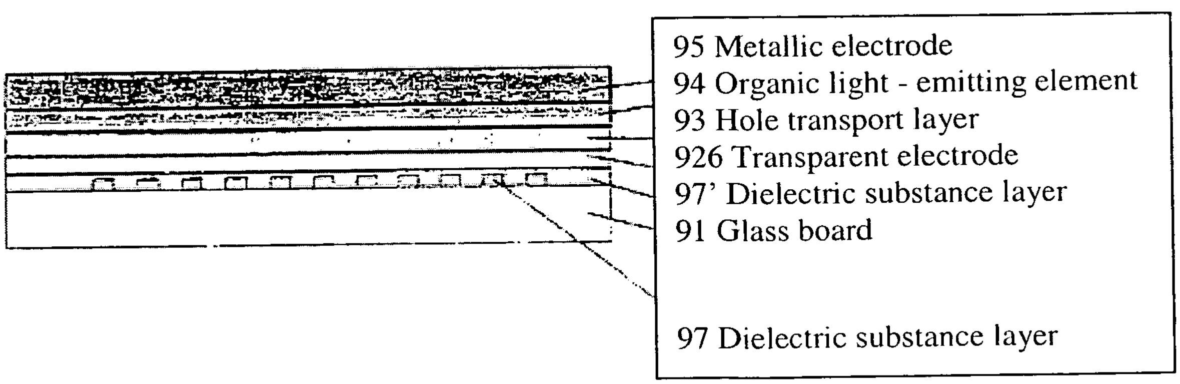
(54) [Title of the Invention] Organic Light - Emitting Elements

(57) [Abstract]

[Topic] An objective is to provide excellent monochromatic Organic Light - Emitting Elements.



[Means for solving the problems] An emission is created by injecting a hole and an electron from a transparent electrode 92 and a metallic electrode 95 on an organic light - emitting layer 94. An emitted light is bounded to an optical waveguide which is formed from the transparent electrode 926 of high refractive index that is provided between an

organic light - emitting layer 94 and a glass board 91 of a low refractive index, and performs parallel direction propagation on the glass board 91 as waveguide light. A periodic distribution of refractive index is formed as per dielectric substance which is formed periodically within an optical waveguide, and a waveguide light performs propagation of the light that is to be diffracted with respect to the light of the specific wave length compliant to that period in reverse direction, therefore resonator is formed, and by this resonator, it is determined that, only the specific wavelength light is strongly emitted.

[Scope of the Claims]

What is claimed is:

[Claim 1] An organic light - emitting elements comprising at least of an anode, an organic thin film layer that contains emitting layer and a cathode on the board, wherein emitting is developed in an emitting layer when a hole and electron was injected from each anode and cathode on an organic thin film layer, and by including area adjacent to the above mentioned optical layer, optically bonded a higher layer of refractive index than the emitting layer with the above mentioned emitting layer, and formed an optical waveguide which performs parallel direction propagation of the light that was emitted by above mentioned emitting layer with respect to the board surface, and an area wherein a full or partial effective refractive index of this optical waveguide changes periodically in a fixed parallel direction with respect to the board surface.

[Claim 2] An organic light - emitting elements comprising at least of an anode, organic thin film layer that contains emitting layer and cathode on the board, wherein emitting is developed in an emitting layer when a hole and electron was injected from each anode and cathode on an organic semiconductor, and amongst anode and cathode at least one has to be transparent, and by including area adjacent to the above mentioned optical layer, optically bonded a higher layer of refractive index than the emitting layer with the above mentioned emitting layer, and formed an optical waveguide which performs parallel direction propagation of the light that was emitted by abovementioned emitting layer with respect to the board surface, a full or partial effective refractive index of abovementioned optical waveguide forms an area which changes periodically in fixed parallel direction with respect to the board surface, and by the above mentioned propagation light and reverse direction light is diffracted and returned, the propagated light and returned light mutually has resonance structure and amongst resonated light, a scattering light or low level diffraction light is discharged on the external portion of the element after transmitting a transparent electrode.

[Claim 3] An organic light - emitting elements comprising a structure of an anode organic thin film layer that contains emitting layer and cathode on the board, and amongst anode and cathode at least one has to be transparent, and an optical waveguide is formed by a higher layer of refractive index that is set adjacent to the emitting layer mentioned above, and in above mentioned optical waveguide, an area wherein that effective refractive index changes periodically is formed, and a fluctuation period of effective refractive index that was formed in above mentioned optical waveguide is a multiple speciation.

[Claim 4] Organic luminescent element mentioned in any of the claims 1 - 3 above, wherein the optical length of period of variation of effective refractive index in the

photoconductive wave path is an integral multiple of half the wavelength of the emitted light.

[Claim 5] Organic luminescent element mentioned in claim 4, wherein the optical length of period of variation of effective refractive index in the photoconductive wave path is half the wavelength of the emitted light.

[Claim 6] Organic luminescent element mentioned in claim 4, wherein the optical length of period of variation of effective refractive index in the photoconductive wave path is the same as the wavelength of the emitted light.

[Claim 7] Organic luminescent element mentioned in any of the claims 1 - 3 above, wherein the region of variation of effective refractive index in the photoconductive wave path is adjacent to the luminescent layer and the light emitted to the outside of the element by passing through the transparent electrode is plane.

[Claim 8] Organic luminescent element consisting of an organic thin film layer comprising at least an anode and luminescent layer and a cathode on a base (board), which emits light from the luminescent layer by injecting a hole and electron from the anode and cathode respectively into the organic thin film. It consists of a transparent layer adjacent to the luminescent layer, having a region of higher refractive index than the luminescent layer and having periodically varying refractive index and, it has a photoconductive wave path having a region where the light emitted by the above mentioned luminescent layer is propagated and the effective refractive index is varied periodically in a fixed direction of the surface of the base.

[Claim 9] Organic luminescent element mentioned in claim 8 above, wherein the photoconductive wave path consists of a transparent electrode having refractive index higher than that of the luminescent layer and the composition of the transparent electrode varies periodically in a fixed direction.

[Claim 10] Organic luminescent element mentioned claim 8 above, wherein the photoconductive wave path consists of a transparent electrode having refractive index higher than that of the luminescent layer and the thickness of the transparent electrode varies periodically in a fixed direction.

[Claim 11] Organic luminescent element consisting of an organic thin film layer comprising at least an anode and luminescent layer and a cathode on a base (board), which emits light from the luminescent layer by injecting a hole and electron from the anode and cathode respectively into the organic thin film. It consists of a transparent layer of higher refractive index than the luminescent layer adjacent to the luminescent layer and a transparent layer having a region of periodically varying refractive index and, it has a photoconductive wave path having a region where the light emitted by the above mentioned luminescent layer is propagated and the effective refractive index is varied periodically in a fixed direction.

[Claim 12] Organic luminescent element wherein at least one from the anode and cathode is transparent, and there is transparent layer on the transparent electrode - side and adjacent to the luminescent layer, having refractive index higher than that of the luminescent layer and a transparent layer adjacent to the luminescent layer or high refractive index layer, having a region of periodically varying refractive index and, it has a photoconductive optical path having a region where the light emitted by the above mentioned luminescent layer is propagated and the effective refractive index is varied periodically in a fixed direction.

[Claim 13] Organic luminescent element mentioned in claim 12, wherein the transparent electrode is made form a layer having refractive index higher that the luminescent layer and there is a transparent layer having a region of periodically varying refractive index adjacent to the luminescent layer or transparent electrode layer and, it has a photoconductive optical path having a region where the light emitted by the above mentioned luminescent layer is propagated and the effective refractive index is varied periodically in a fixed direction.

[Claim 14] Organic luminescent element mentioned in claim 11, wherein the transparent layer having a region of periodically varying refractive index consists of an organic thin film layer and composition of the organic thin film layer periodically varies in a definite direction.

[Claim 15] Organic luminescent element mentioned in claim 11, wherein the transparent layer having a region of periodically varying refractive index consists of a dielectric layer and composition of the dielectric layer periodically varies in a definite direction.

[Claim 16] Organic luminescent element mentioned in claim 11, wherein the transparent layer having a region of periodically varying refractive index consists of a dielectric layer, and thickness of the dielectric layer periodically varies in a definite direction.

[Claim17] Organic luminescent element mentioned in claim 11, wherein the transparent layer having a region of periodically varying refractive index consists of several dielectric layers and thickness or composition of the dielectric layers periodically varies in a definite direction.

[Claim 18] Organic luminescent element mentioned in claim 3, wherein the fluctuation period of effective refractive index in the photoconductive wave path is of several types, which correspond to red, green and blue light.

Detailed description of the invention

[0001] **Fields related to this invention**

This invention is related to organic luminescent element making use of an organic semiconductor.

[0002] **Conventional techniques**

with the development of high degree informatics and multimedia age, there is brisk activity in the development of flat display elements with low power consumption and high definition images. Non - luminescent liquid crystal displays have established their position as low power consuming elements and efforts are going on for increasing their performance for the application to portable information terminals. On the other hand, organic EL display is self luminescent type and it is easily recognizable most commonly for indoor - use. Because of this, active research for the development of replacement of CRT or large screen display (which is difficult in CRT), or super definition display is in progress. Monochromatic (green or yellow) alphanumeric displaying technique has reached the level of practical application. Now onwards, the expectations for bright and thin type display and high definition color display for displaying moving images by making use of special features of organic EL are increasing.

[0003] By providing an electrode layer for introducing a hole on a glass board, an organic layer for transporting the hole, an organic luminescent layer for transporting the electron and an electrode layer for introducing electron, Tang el al [Ref. C.W Tang et al. Appl. Phys. Lett. Vol. 51, p913 (1987)] have shown in 1987 that an organic EL can emit light at a low voltage. This created a lot of interest in organic EL elements.

[0004] Fig. 11 shows an outline of the conventional organic EL element proposed by Tang el al. It has an anode 112 made of a transparent electrically conducting thin layer of Indium tin oxide (ITO) on a glass base 111, which has a relatively high ionization potential is easy for introduction of a hole. Almost all over the surface of it, there is a hole - transporting layer 113, and electron transporting layer 114 in that order. On its surface there is a cathode 115 which is made of al alloy like silver magnesium alloy (AgMg) having relatively lower work function for easy introduction of electrons.

[0005] The electron transporting layer 114 has a lower work function as compared to common metals, but the introduction and transporting of electrons is made easy by making use of an alloy like AgMg having lower work function for the cathode. Further, as the hole - transporting layer 113 has relatively high ionization potential and, the material like gold (Au) or indium tin oxide (ITO) having high ionization potential is used for the anode, the introduction and transporting of holes becomes easy. Here, holes are introduced from the anode (ITO) 112 to the hole - transporting layer 113 by applying positive direct current potential to the anode with respect to the cathode. Further, electrons are introduced from the cathode 115 to the electron transporting layer 114 and, by bonding them in the luminescent layer adjacent to the portion connecting the hole transporting layer 113 and electron transport layer 114; excited electrons are produced to get green colored light 116. This light is observed after it passes through transparent electrodes and the base Of course, light emission can be obtained by transporting the holes and electrons by connecting the hole - transporting organic luminescent layer and electron transporting organic layer, by introducing and transporting holes and electrons.

[0006] This principle of light emission is similar to that in case of inorganic light emitting diodes made from gallium and arsenic. This corresponds to introducing electrons and holes into a semiconductor having PN junction and then bonding them again in the vicinity of the junction so that light is emitted. Moreover, electron transporting layer corresponds to N type semiconductor and a hole - transporting layer corresponds to P type semiconductor.

[0007] After that organic semiconductor material or additive material for emitting blue or red color was developed and several methods for bringing into practice color display have been proposed and, color display is also being tried. Following five are the methods for bringing into practice color display.

[0008] (1) To arrange 3 types of organic luminescent materials alternately, which emit planar red, green and blue light.

[0009] (2) To laminate 3 types of organic luminescent materials that emit red, green and blue light.
(3) To make organic material that emits white color (wide band of green) and 3 types of resonating structures.

[0010] (4) Method of combining white color - emitting organic material with color - filter of 3 basic colors.

[0011] (5) Method of combining blue color - emitting organic material and color exchange layer that changes into the 3 basic colors.

[0012] However, there are big problems in these methods. In the first method, minute processing of the thin film produced once becomes difficult because the organic material has problems regarding water resistance and solvent resistance, and thus it becomes extremely difficult to obtain a precise display.
[0013] In method 2, the heat resistance of the organic film is insufficient and therefore, it is difficult to form a laminated ITO layer having high transparency. Further, as it is necessary to use a metal having lower value of work function for the cathode in case of organic EL, it is almost impossible to get a laminated element having high transparency. Thus, in this method, it is extremely difficult to get a color display with good efficiency.

[0014] In method 3, it is extremely difficult to get a color display which is uniform over a large area for the emitted color to exist on the thickness of the thin film for forming resonator.

[0015] Methods 4 and 5 are better for high quality images, but in method 4, as color filters are used, it is not possible to get high performance display and at present, one has to wait for the development of high white colored material. Further, in method 5, the efficiency of conversion from blue to red is low and thus it is difficult to get a highly efficient and highly bright display.

[0016] **Problem to be solved**
As stated above, it is difficult to get high quality color display in practice, by means of the conventional technique.

[0017] This invention presents a new method of controlling the wavelength of luminescent element, based on a new principle and, new type of color display. Especially by overcoming the defects of the conventional color display systems, it brings into practice the high quality images and highly reliable color display.

[0018] **Solution to the problem**
For solving the problem, the organic luminescent element of this invention has an organic thin film containing at least an anode, luminescent layer and a cathode on the base. Luminescence is generated by means of the luminescent layer, by introducing holes and electrons respectively from anode and cathode into the organic thin film layer. A layer having refractive index higher than that of the above luminescent layer is optically bonded to the above luminescent layer including the region adjacent to the luminescent layer and it has a photoconductive optical path, which transports the light emitted by the luminescent layer to a direction parallel to the base. On a portion of the photoconductive layer or all over of it, there is a region where the refractive index undergoes periodic variation in a definite direction parallel to the surface of the base.

[0019] Further, in the organic luminescent element consisting of an organic thin film layer comprising at least anode and luminescent layer and a cathode on a base (board), which emits light from the luminescent layer by introducing a hole and electron from the anode and cathode respectively into the organic thin film, at least one from the anode and cathode is transparent and there is a layer adjacent to the luminescent layer having refractive index higher that that of the luminescent layer and it has a photoconductive optical path, which transports the light emitted by the luminescent layer to a direction parallel to the base. By returning the light in the direction opposite to that of the propagation of light, the transported light and returned light are made to resonate. Scattered light and low level refracted light are emitted out of the element by passing them through the transparent electrode.

[0020]With this structure, it is possible to get high picture quality image with highly reliable monochromatic emission wavelength and highly reliable color display.

[0021] **Practical application of the invention**
Invention of claim 1 is an organic luminescent element which has an organic thin film containing at least an anode, luminescent layer and a cathode on the base (board). Luminescence is generated by means of the luminescent layer, by introducing holes and electrons respectively from anode and cathode into the organic thin film layer. A layer having refractive index higher than that of the above luminescent layer is optically bonded to the above luminescent layer including the region adjacent to the luminescent layer and it has a photoconductive optical path, which transports the light emitted by the luminescent layer to a direction parallel to the base. On one portion of the photoconductive layer or all over of it, there is a region where the refractive index

undergoes periodic variation in a definite direction parallel to the surface of the base. It strongly emits light of a specific wavelength according to the periodic variation of the effective refractive index, to give light of high color purity.

[0022] Invention of claim 2 is an organic luminescent element which has an organic thin film containing at least an anode, luminescent layer and a cathode on the base (board). Luminescence is generated by means of the luminescent layer, by introducing holes and electrons respectively from anode and cathode into the organic thin film layer. At least one from the anode and cathode is transparent. There is a layer having refractive index higher than that of the above luminescent layer and, a photoconductive optical path, which transports the light emitted by the luminescent layer to a direction parallel to the base. On one portion of the photoconductive layer or on all over of it, there is a region where the refractive index undergoes periodic variation in a definite direction parallel to the surface of the base. By returning the light in the direction opposite to that of the propagation of light, the transported light and returned light are made to resonate. Scattered light and low level refracted light from the resonating light are emitted out of the element by passing them through the transparent electrode.

[0023] Invention of claim 3 is organic luminescent element which has an organic thin film containing at least an anode, luminescent layer and a cathode on the base (board). At least one from the anode and cathode is transparent. There is a photoconductive path made of above luminescent layer and the adjacent layer of high refractive index. There is a region in the optical path where the effective refractive index periodically varies. There are several periods of variation of effective refractive index. The element strongly emits light of a specific wavelength according to the periodic variation of the effective refractive index, to give various types of light emission of high color purity.

[0024] Invention of claim 4 gives organic luminescent element mentioned in claims 1 to 3, wherein optical length of the period of variation of effective refractive index is integral multiple of half the wavelength of emitted light.

[0025] Invention of claim 5 gives organic luminescent element mentioned in claim 4 wherein optical length of the period of variation of effective refractive index in the optical path is half the wavelength of emitted light.

[0026] Invention of claim 6 gives organic luminescent element mentioned in claim 4 wherein optical length of the period of variation of effective refractive index in the optical path is the same as the wavelength of the emitted light. By doing this, the secondary refraction is made to resonate and primary refracted light is emitted out of the luminescent element.

[0027] Invention of claim 7 gives organic luminescent element mentioned in any of the claims 1 to 3, wherein the region of periodic variation of refractive index in the photoconductive wave path is generated adjacent to the luminescent layer and the light emitted out of the element by passing through the transparent electrode is planar.

[0028] Invention of claim 8 is an organic luminescent element which has an organic thin film containing at least an anode, luminescent layer and a cathode on the base (board). Luminescence is generated by means of the luminescent layer, by introducing holes and electrons respectively from anode and cathode into the organic thin film layer. There is a transparent layer adjacent to the luminescent layer, having a region of refractive index higher than that of the above luminescent layer and, where the refractive index varies periodically. There is a photoconductive wave path layer, which transports the light emitted by the luminescent layer and where the effective refractive index undergoes periodic variation in a definite direction of the surface of the base. It strongly emits several lights of specific wavelengths according to the periodic variation of the effective refractive index, to give light of high color purity.

[0029] Invention of claim 9 is organic luminescent element mentioned in claim 8 wherein there is a photoconductive wave path having a transparent electrode, which has refractive index higher that that of the luminescent layer and composition of the transparent electrode periodically varies in a specific direction.

[0030] Invention of claim 10 gives organic luminescent element mentioned in claim 8 wherein there is a photoconductive wave path having a transparent electrode, which has refractive index higher that that of the luminescent layer and thickness of the transparent electrode periodically varies in a specific direction.

[0031] Invention of claim 11 an organic luminescent element which has an organic thin film containing at least an anode, luminescent layer and a cathode on the base (board). Luminescence is generated by means of the luminescent layer, by introducing holes and electrons respectively from anode and cathode into the organic thin film layer. There is a transparent layer adjacent to the luminescent layer, having a region of refractive index higher than that of the above luminescent layer and a transparent electrode layer having a region where the refractive index varies periodically and, it has a photoconductive optical path, which transports the light emitted by the luminescent layer and where the effective refractive index undergoes periodic variation in a definite direction of the surface of the base. It strongly emits several lights of specific wavelengths according to the periodic variation of the effective refractive index, to give high color purity.

[0032] Invention of claim 12 is organic luminescent element wherein at least one of the electrodes from the anode and cathode is transparent. Adjacent to the luminescent layer and on the transparent electrode side, there is a transparent layer having refractive index higher than that of the luminescent layer and, there is a transparent layer adjacent to the luminescent layer (or layer of higher refractive index), having a region where the refractive index varies periodically and, it has a photoconductive optical path, which transports the light emitted by the luminescent layer and, where the effective refractive index undergoes periodic variation in a definite direction of the surface of the base. It strongly emits several lights of specific wavelengths according to the periodic variation of the effective refractive index, to give high color purity.

[0033] Invention of claim 13 is organic luminescent element mentioned in claim 12, wherein the transparent electrode has refractive index higher than that of the luminescent layer and adjacent to the luminescent layer or transparent electrode layer, there is a transparent layer having a region where the refractive index varies periodically and it has a photoconductive optical path, which transports the light emitted by the luminescent layer and where the effective refractive index undergoes periodic variation in a definite direction of the surface of the base.

[0034] Invention of claim 14 is organic luminescent element mentioned in claim 11, wherein the transparent layer of periodically varying refractive index is made of an organic thin film and the composition of the organic thin film varies periodically in a specific direction.

[0035] Invention of claim 15 is organic luminescent element mentioned in claim 11, wherein the transparent layer of periodically varying refractive index is made of a dielectric layer and the composition of the dielectric layer varies periodically in a specific direction.

[0036] Invention of claim 16 is organic luminescent element mentioned in claim 11, wherein the transparent layer of periodically varying refractive index is made of a dielectric layer and the thickness of the dielectric layer varies periodically in a specific direction.

[0037] Invention of claim 17 is organic luminescent element mentioned in claim 11, wherein the transparent layer of periodically varying refractive index is made of several dielectric layers and thickness or composition of at least one of the dielectric layers varies periodically in a specific direction.

[0038] Invention of claim 18 is organic luminescent element mentioned in claim 3, wherein fluctuation period of effective refractive index in the photoconductive wave path is of several types corresponding to red, green and blue light and thus colored image display has become possible.

[0039] **Practical application 1**

Outline of the principle of the organic luminescent element of this invention is explained with reference to Fig. 1. Fig. 1 (A) is layer sectional diagram of the luminescent element. Fig. 1 (B) shows refractive indices and intensity distribution of light of various layers.

[0040] In Fig. 1 (A), 1 is glass base plate. On its surface there is transparent electrode 2, periodic high refractive index layer 6, which is a transparent semiconductor layer having refractive index higher than that of the organic semiconductor layer (consisting of the luminescent layer), and which changes periodically. There is an organic luminescent layer 4 made of an organic semiconductor film and, a metallic electrode 5, in that order. Light emission is generated by introducing carriers from the transparent electrode 2 and metallic electrode 5 into the luminescent layer of the organic luminescent layer 4. However, as shown in Fig. 1 (B), as there is layer 6 of periodically varying refractive

index adjacent to the organic luminescent layer 4, the generated light gets confined to layers at both ends of low refractive index (that is, in periodic high refractive index layer 6 or its vicinity), which is sandwiched between the organic layer 4 and glass base 1 and, the generated light propagates as photoconductive wave path, in a direction parallel to the glass base 1. However, in the waveguide path, there is refractive index distribution of a definite period (due to the periodic high refractive index layer) and therefore, only the light 8 from the photoconductive wave path 7 (propagating the photoconductive wave path and having specific wavelength according to the period) is reflected in the opposite direction due to refraction phenomenon. Then, the propagating light having a wavelength identical to that of the reflected light interfere constructively and resonance occurs in the direction parallel to the glass base with a specific wavelength. As a result, out of the light generated at the organic layer 4, only the light of a specific wavelength determined by the resonance is emitted intensely. Further, the light confined in the photoconductive type resonator is emitted out of the base, by passing through glass plate, due to scattering inside the waveguide path.

[0041] In this case, if optical path of varying period of effective refractive index of periodic photoconductive wave path is integral multiple of the wavelength of the emitted light, then light with low (secondary) refraction can be taken out. For example, if it is almost the same as the wavelength of the emitted light, then primary refraction 9 is emitted in a direction perpendicular to the base.

[0042] In the luminescent element having this type of structure, spectrum of the emitted light is close to the resonating wave length and it gives light of extremely high purity of color. Thus, by making the variation periods of effective refractive index corresponding to red, green and blue light, it is possible to get light of extremely high purity of color.

[0043] Usually in case of a conductive wave path having periodic refractive index, only the propagating light having its direction of vibration parallel to that of the periodic structure gets diffracted and therefore, the light emitted to the outside from the waveguide path of the periodic structure has its polarized component mostly in the direction of the periodic structure. Thus, direction of polarization of the emitted light can be controlled by controlling the direction of the periodic structure.

[0044] In the working examples of this invention, periodic high refractive index layer 6 is situated between the organic luminescent layer 4 and transparent electrode 2. It has higher refractive index than both the layer 4 and electrode 2 and periodic refractive index distribution. This forms a waveguide path for feedback. However, high refractive index layer and a layer having periodic refractive index distribution may be prepared separately. By this structure also, it is possible to form photoconductive path having periodically varying refractive index.

[0045] Further, in this invention, a high refractive index layer 6 having refractive index higher than the transparent electrode 2 is used for forming the photoconductive wave path. However, refractive index higher than that of the transparent electrode 2 may not be necessary. For example, if the refractive index of the transparent electrode 2 is greater

than the organic luminescent layer 4, then a photoconductive wave path mainly having the transparent electrode as the main body is formed. Thus, if there is a layer adjacent to the transparent electrode 2 having periodic refractive index distribution, then a photoconductive wave path with periodic distribution of effective refractive index is formed and wave guide type resonance occurs.

[0046] Further, in this invention, periodic high refractive index layer 6 having periodic refractive index distribution is situated between the organic luminescent layer 4 and transparent electrode 2, but it may not be necessarily situated between the organic luminescent layer 4 and transparent electrode 2. For example, it may be situated between the transparent electrode 2 and glass base1 or, it may be between the organic luminescent layer 4 and metallic electrode 5.

[0047] **Practical application 2**

Composition of a specific organic luminescent element of this invention is explained below. Organic luminescent element of this invention concerning practical application 2 is explained with reference to Fig. 2.

[0048] In Fig. 2, there is a glass base 21. On the surface of glass base 21, there is a transparent dielectric layer 267 having 2 types of dielectric of high refractive index (such as titanium oxide and zinc sulfide) arranged alternately and on this, there is the anode, which is a transparent electrode layer 22 made of indium tin oxide. On the surface of the transparent electrode layer 22, the hole transport layer 23 made from triphenyldiamine (TPD[N,N' – bis (3 - methylphenyl) - (1, 1' - biphenyl) - 4, 4' - diamine] is situated and on this, there is an organic luminescent layer 24 for electron transport, made from an organic semiconductor like aluminium - quinolenol complex (Alq[tris (8hydroxyquinoline) aluminium]) and metallic electrode 25 serving as cathode, in that order. From the anode 22 and cathode 25, holes and electrons are respectively introduced into the organic luminescent layer 24, to produce emission of light.

[0049] Here, with the principle same as explained in practical application 1, because of the high refractive index of the dielectric layer 267 situated adjacent to the organic luminescent layer 24, the emitted light gets confined to close to the dielectric layer 267, which is sandwiched between the two layers or media of low refractive index (that is, organic luminescent layer 24 and the glass base 21) and the light thus generated is propagated in the direction parallel to the glass base 21, as waveguide light. As there is periodic distribution of refractive index on the dielectric layer 267, periodic distribution of effective refractive index occurs on the waveguide path of the propagating light. Thus, as explained in practical application 1, resonance occurs in the glass base 21 and its parallel direction and, out of the light emitted from the organic luminescent layer 24, only the light of specific wavelength determined by the resonator is generated and strongly emitted outside.

[0050] **Practical application 3**

In practical application 2, the dielectric layer 267 is such that it has periodic distribution of refractive index. However, the transparent electrode itself may have periodic

distribution of refractive index. Specific example of element structure is explained as practical application 3, with reference to Fig. 3.

[0051] In Fig. 3, the glass base is 31. The anode made from transparent electrode 3267of indium tin oxide with periodically varying composition ratio is on its surface. On its surface, there are hole transport layer 33 made from triphenyl diamine (TPD[N,N' - bis (3 - methylphenyl) - (1, 1' - biphenyl) - 4, 4' - diamine], electron transport layer 34, which is an organic semiconductor made from aluminium quinolinol complex (Alq[tris (8hydroxyquinoline) aluminium]) and the cathode (metallic electrode 35) are situated in that order. From the anode 3267 and cathode 35, holes and electrons are introduced into the organic luminescent layer and light is emitted.

[0052] Here, as explained in practical application 1, as the transparent electrode 3267 situated adjacent to the organic luminescent layer 34 has high refractive index, the generated light gets confined close to the transparent electrode sandwiched between the two layers of low refractive index (that is the organic luminescent layer 34 and glass base31, the generated light propagates as a wave guide light, along the direction parallel to the glass base 31. As the transparent electrode 3267 has periodic distribution of refractive index, a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 31 and, out of the light generated in the organic luminescent layer 34, only the light of a specific wavelength determined by the resonator is emitted strongly outside.

[0053] **Practical application 4**
Organic luminescent element of this invention concerning practical application 4 is explained with reference to Fig. 4.

[0054] In Fig. 4, the glass base is 41. The anode made from transparent electrode 4267 of indium tin oxide is on its surface. The thickness of transparent electrode 4267 varies periodically and it has periodic ups and downs on its surface. On the surface of the transparent electrode 4267, there is hole transport layer 43 made from triphenyl diamine (TPD [N, N' - bis (3 - methylphenyl) - (1, 1' - biphenyl) - 4, 4' - diamine]. On this, there is electron transport layer 44, which is an organic semiconductor made from aluminium qunolinol complex (Alq[tris (8hydroxyquinoline) aluminium]) and the cathode (metallic electrode 35) and there is the cathode made of metallic electrode 45 and they are situated in that order. From the anode 4267 and cathode 45, holes and electrons are introduced into the organic luminescent layer 44 and light is emitted.

[0055] Here, as explained in practical application 1, as the transparent electrode 4267 situated adjacent to the organic luminescent layer 44 has high refractive index, the generated light gets confined close to the transparent electrode sandwiched between the two layers of low refractive index (that is the organic luminescent layer 44 and glass base 41) and, the generated light propagates as a wave guide light, along the direction parallel to the glass base 41. As periodic variation of refractive index takes place due to

the periodic ups and down in the transparent electrode 4267, a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 41 and out of the light generated in the organic luminescent layer 44, only the light of a specific wavelength determined by the resonator is emitted strongly outside.

[0056] **Practical application 5**
Organic luminescent element of this invention concerning practical application 5 is explained with reference to Fig. 5.

[0057] In Fig. 5, the glass base is 51. A dielectric layer 56 having high refractive index is situated on the glass base 51. The anode made from transparent electrode 52 of indium tin oxide is on its surface. On the surface of the transparent electrode 52, there is hole introducing layer 57. On the hole - introducing layer 57, there is hole - transport layer 53 made of triphenyl diamine (TPD [N,N' - bis (3 - methylphenyl) - (1,1' - biphenyl) - 4,4' - diamine]. On this, there is electron transport layer 54, which is an organic semiconductor made from aluminium qunolinol complex (Alq[tris (8hydroxyquinoline) aluminium]) and the cathode (metallic electrode 35) and there is the cathode made of metallic electrode 55, and they are situated in that order. From the anode 52 and cathode 55, holes and electrons are introduced into the organic luminescent layer 54 and light is emitted.

[0058] Here, as explained in practical application 1, as the dielectric layer 56 situated adjacent to the organic luminescent layer 54 has high refractive index, the generated light gets confined close to the dielectric electrode layer 52 sandwiched between the two layers of low refractive index (that is the organic luminescent layer 54 and glass base 51) and, the generated light propagates as a wave guide light, along the direction parallel to the base. As periodic variation of refractive index takes place on the hole - introduction layer 57, a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 51 and, out of the light generated in the organic luminescent layer 54, only the light of a specific wavelength determined by the resonator is emitted strongly outside.

[0059] **Practical application 6**
Organic luminescent element of this invention concerning practical application 6 is explained with reference to Fig. 6.

[0060] In Fig. 6, the glass base is 61. A transparent electrode 626 having high refractive index and made of indium tin oxide layer is situated on the glass base 61. On the surface of the transparent electrode 626, there is a hole - introducing layer 67 having periodic refractive index. On the hole - introducing layer 67, there is the hole - transport layer 63 made of triphenyl diamine (TPD [N,N' - bis (3 - methylphenyl) - (1,1' - biphenyl) -

4,4' - diamine]. On this, there is electron transport layer 64, which is an organic semiconductor made from aluminium qunolinol complex (Alq[tris (8 - hydroxyquinoline) aluminium]) and the cathode (metallic electrode 65) and they are situated in that order. From the anode 626 and cathode 65, holes and electrons are introduced into the organic luminescent layer 64 and light is emitted.

[0061] Here, as explained in practical application 1, as the transparent electrode 626 situated adjacent to the organic luminescent layer 64 has high refractive index, the generated light gets confined close to the dielectric electrode layer 626 sandwiched between the two layers or media of low refractive index (that is the organic luminescent layer 64 and glass base 61) and, the generated light propagates as a wave guide light, along the direction parallel to the glass base 61. As periodic variation of refractive index takes place on the hole - introduction layer 67, a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 61 and, out of the light generated in the organic luminescent layer 64, only the light of a specific wavelength determined by the resonator is emitted strongly outside.

[0062] **Practical application 7**

Organic luminescent element of this invention concerning practical application 7 is explained with reference to Fig. 7.

[0063] In Fig. 7, the glass base is 71. On the glass base 71, two dielectric layers 77 having a periodically repeated structure of two dielectric substances of different refractive indices (such as silicon oxide and titanium oxide) giving periodic refractive index structure and, a transparent electrode 726 of high refractive index (transparent electrode made from indium tin oxide) are situated. On the surface of the transparent electrode 726, there is a hole transport layer 73 made of triphenyl diamine (TPD [N,N' - bis (3 - methylphenyl) - (1, 1' - biphenyl) - 4, 4' - diamine]. On this, there is electron transport layer 74, which is made from aluminium qunolinol complex (Alq[tris (8 - hydroxyquinoline) aluminium]) and the cathode (metallic electrode 75) and they are situated in that order. From the anode 726 and cathode 75, holes and electrons are introduced into the organic luminescent layer 74 and light is emitted.

[0064] Here, as explained in practical application 1, as the transparent electrode 726 situated adjacent to the organic luminescent layer 74 has high refractive index, the generated light gets confined close to the dielectric electrode layer 626 sandwiched between the two layers or media of low refractive index (that is the organic luminescent layer 74 and glass base 71) and, the generated light propagates as a wave guide light, along the direction parallel to the glass base 71. As periodic variation of refractive index takes place on the hole - introduction layer 77, a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass

base 71 and, out of the light generated in the organic luminescent layer 74, only the light of a specific wavelength determined by the resonator is emitted strongly outside.

[0065] **Practical application 8**
Organic luminescent element of this invention concerning practical application 8 is explained with reference to Fig. 8.

[0066] In Fig. 8, the glass base is 81. On the glass base 81, there is dielectric layer 87 having ups and downs on its surface. A transparent electrode 826 covers this uneven structure. On the transparent electrode, there is the hole transport layer 83 made of triphenyl diamine (TPD [N,N' - bis (3 - methylphenyl) - (1,1' - biphenyl) - 4,4' - diamine]. On this, there is electron transport layer 84, which is made from aluminium qunolinol complex (Alq[tris (8 - hydroxyquinoline) aluminium]) and the cathode (metallic electrode 85) and they are situated in that order. From the anode 826 and cathode 85 respectively, holes and electrons are introduced into the organic luminescent layer 84 and light is emitted.

[0067] Here, as explained in practical application 1, as the transparent electrode 826 situated adjacent to the organic luminescent layer 84 has high refractive index, the generated light gets confined close to the transparent electrode layer 826 sandwiched between the two layers or media of low refractive index (that is the organic luminescent layer 84 and glass base 81) and, the generated light propagates as a wave guide light, along the direction parallel to the glass base 81. As periodic variation of refractive index takes place on the transparent electrode layer 87, a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 81 and, out of the light generated in the organic luminescent layer 874, only the light of a specific wavelength determined by the resonator is emitted strongly outside.

[0068] **Practical application 9**
Organic luminescent element of this invention concerning practical application 9 is explained with reference to Fig. 9.

[0069] In Fig. 9, the glass base is 91. On the glass base 91, there is striped dielectric layer 97. This is covered by a dielectric 97' having refractive index different from that of the dielectric 97. On the dielectric layer 97', there is a transparent electrode 926 having high refractive index, and made of indium tin oxide. On the transparent electrode 926, there is the hole transport layer 93 made of triphenyl diamine (TPD [N,N' - bis (3 - methylphenyl) - (1, 1' - biphenyl) - 4, 4' - diamine]. On this, there is electron transport layer 94, which is made from aluminium qunolinol complex (Alq[tris (8 - hydroxyquinoline) aluminium]) and the cathode (metallic electrode 95) and they are situated in that order. From the anode 926 and cathode 95 respectively, holes and electrons are respectively introduced into the organic luminescent layer 94 and light is emitted. Here, as explained in practical application 1, as the transparent electrode 926 situated adjacent to the organic luminescent layer 84 has high refractive index, the

generated light gets confined close to the transparent electrode layer 926 sandwiched between the two layers or media of low refractive index (that is the organic luminescent layer 94 and glass base 91) and, the generated light propagates as a wave guide light, along the direction parallel to the glass base 91. As periodic variation of refractive index takes place by the dielectric layers 97 and 97', a periodic distribution of effective refractive index is formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 91 and, out of the light generated in the organic luminescent layer 94, only the light of a specific wavelength (determined by the resonator) is strongly emitted outside.

[0070] **Practical application 10**
Organic luminescent element of this invention concerning practical application 10 is explained with reference to Fig. 10.

[0071] In Fig. 10, the glass base is 101. On the glass base 101, there are two striped alternate dielectrics 107 and 117 of different period - width 97. This is covered by a dielectric layer 127' having refractive index different from that of the dielectrics 107, and 117. This layer is covered by another dielectric layer 127 having refractive index different from the striped dielectric layers 107 and 117. On the dielectric layer 127, there is a transparent electrode 1026 having high refractive index, and made of indium tin oxide. On the transparent electrode 1026, there is the hole transport layer 103 made of triphenyl diamine (TPD [N, N' - bis (3 - methylphenyl) - (1,1' - biphenyl) - 4,4' - diamine]. On this, there is electron transport layer 104, which is made from aluminium qunolinol complex (Alq[tris (8 - hydroxyquinoline) aluminium]) and the cathode (metallic electrode 105) and they are situated in that order. From the anode 1026 and cathode 105 respectively, holes and electrons are respectively introduced into the organic luminescent layer 104 and light is emitted.

[0072] Here, as explained in practical application 1, as the transparent electrode 1026 situated adjacent to the organic luminescent layer 104 has high refractive index, the generated light gets confined close to the transparent electrode layer 1026 sandwiched between the two layers or media of low refractive index (that is the organic luminescent layer 104 and glass base 101) and, the generated light propagates as a wave guide light, along the direction parallel to the glass base 101. As two periodic refractive index distributions take place by the dielectric layers 107 and 117 and 127, two periodic distributions of effective refractive index are formed in the photoconductive path of the propagating light. Thus, as explained in practical example 1, due to the periodic distribution of effective refractive index created in the photoconductive path, a resonance occurs in the direction of the glass base 101 and, out of the light generated in the organic luminescent layer 104, only the light of a specific wavelength (determined by the resonator) is strongly emitted outside. This time, as the resonator has two different periodic refractive index distributions, the light is of wavelength 1 and wavelength 2 and, these two colors are emitted.

[0073] By constructing one more refractive index distribution in the dielectric layer, it is possible to emit 3 colors of light. If the colors correspond to red, blue and green, emission of 3 basic colors is possible and thus color display is obtained.

[0074] **Effect of the invention**

This invention presents an organic luminescent element consisting of an organic thin film layer comprising at least anode and luminescent layer and a cathode on a base (board), which emits light from the luminescent layer by introducing a hole and electron from the anode and cathode respectively into the organic thin film. In this, a photoconductive wave path having periodic refractive index in the direction of the surface of the base is created and a light of wavelength corresponding to the periodic structure is emitted. It is therefore possible to emit light of desired wavelength and single color and thus high quality color display is made possible.

Brief description of the invention

Fig. 1: (A) Sectional diagram of luminescent element of this invention from practical application 1

(B) Diagram showing the refractive index and intensity of light of each layer

Fig. 2: Sectional diagram of luminescent element of this invention from practical application 2

Fig. 3: Sectional diagram of luminescent element of this invention from practical application 3

Fig. 4: Sectional diagram of luminescent element of this invention from practical application 4

Fig. 5: Sectional diagram of luminescent element of this invention from practical application 5

Fig. 6: Sectional diagram of luminescent element of this invention from practical application 6

Fig. 7: Sectional diagram of luminescent element of this invention from practical application 7

Fig. 8: Sectional diagram of luminescent element of this invention from practical application 8

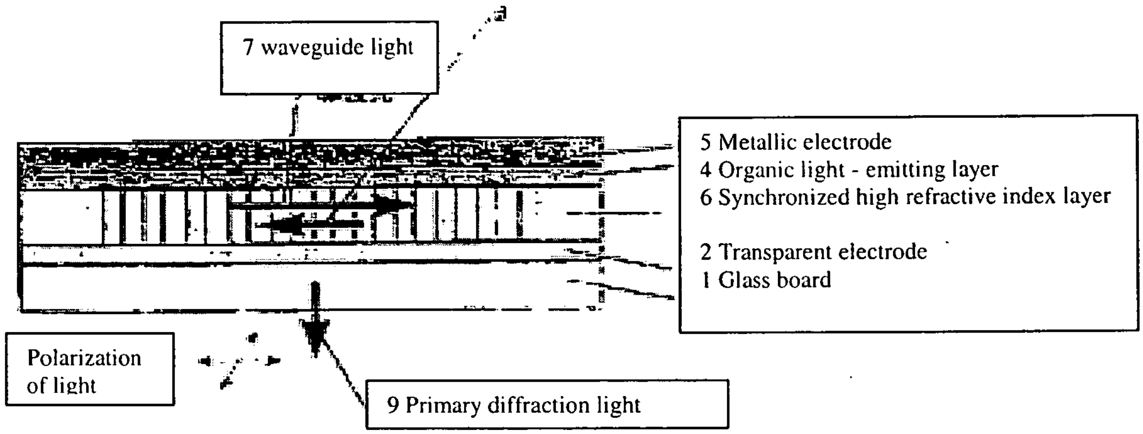
Fig. 9: Sectional diagram of luminescent element of this invention from practical application 9

Fig. 10: Sectional diagram of luminescent element of this invention from practical application 10

Fig. 11: Sectional diagrams of conventional organic luminescent element

Figure 1]

(A)



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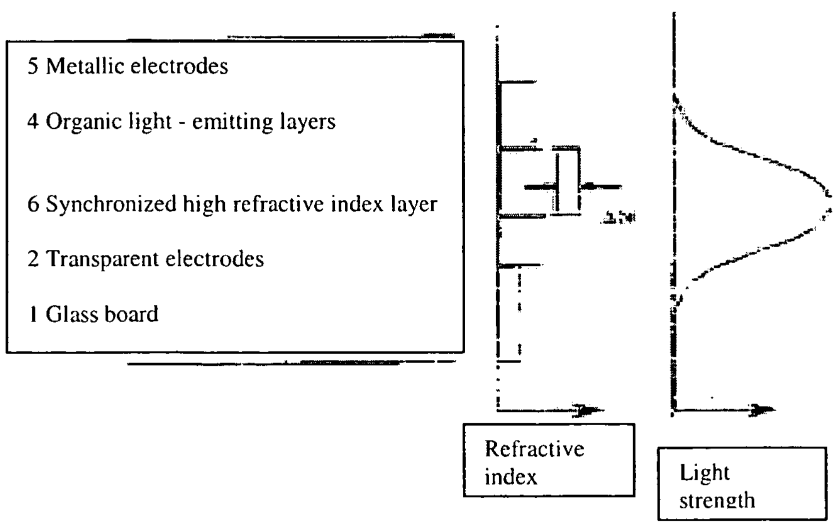
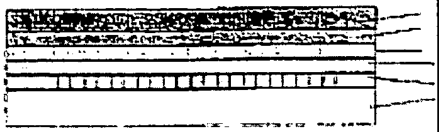
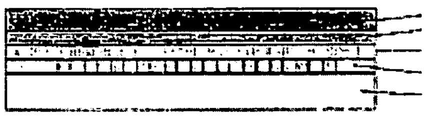


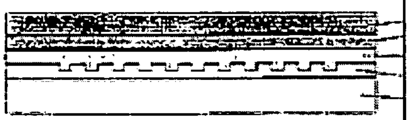
[Figure 2]



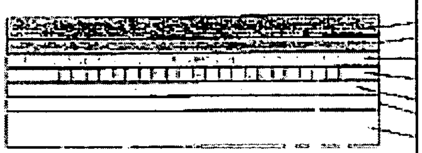
[Figure 3]



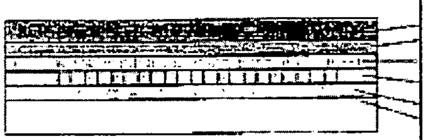
[Figure 4]



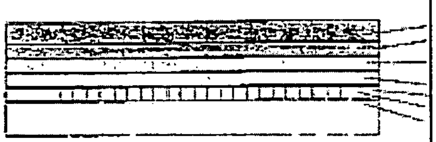
[Figure 5]



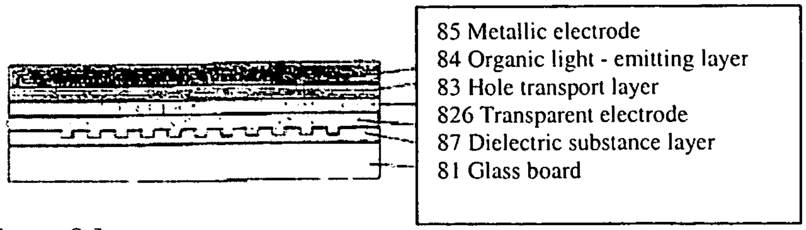
[Figure 6]



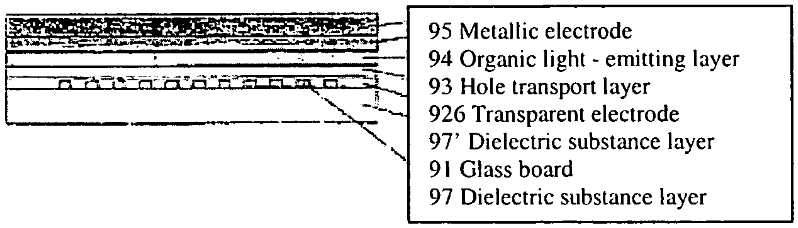
[Figure 7]



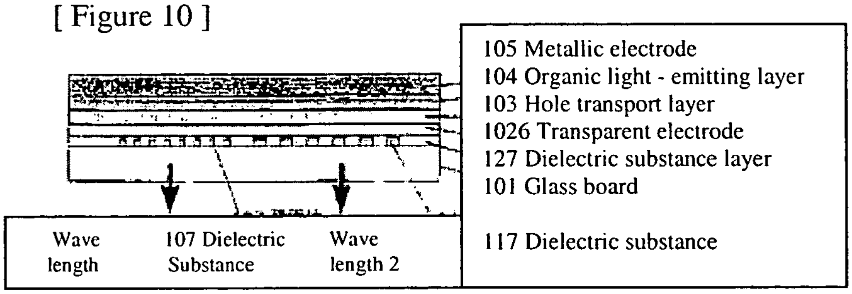
[Figure 8]



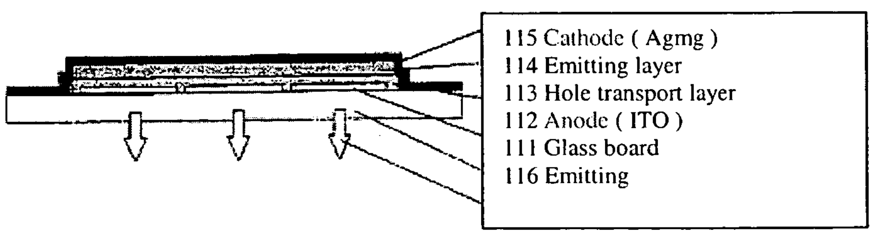
[Figure 9]



[Figure 10]



[Figure 11]



Description of symbols

1, 21, 31, 41, 51, 61, 71, 81, 91, 101: Glass base

2. 22. 3267, 4267, 52, 626, 726, 826, 926, 1026: transparent electrodes

4, 24, 34, 44, 54, 64, 74, 84, 94, 104: organic luminescent layers

5, 25, 35, 45, 55, 65, 75, 85, 95, 105: metallic electrodes

6: High refractive index layer

23, 33, 43, 53, 63, 73, 83, 93, 103: hole - transport layers

267, 56, 77, 87, 97, 97', 107, 117, 127: dielectric

57, 67: hole - introduction layers.

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